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THE GNOMONIC PROJECTION

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The crystal is conceived as having a sphere described about its center (sphere of projection), radii of which may be drawn normal to the crystal faces. The points at which the face-normals intersect the sphere are called the poles of the faces and are defined if we know for each two angles: φ the azimuth angle (longitude) referred to a first or zero meridian; and ρ the polar distance (co-latitude).

In figure 5 a face-normal is represented by the pole F′, defined by the angles φ and ρ,—angles which can be measured on the two-circle goniometer.

The gnomonic projection is obtained if the face-normals are extended until they intersect a plane tangent to the sphere of projection. The crystal is generally placed with its vertical zone-axis (prism zone) parallel to the vertical diameter of the sphere; the plane of projection is made normal to this and is therefore tangent to the sphere at the north pole and parallel to the plane of the equator. The plane of projection is therefore parallel to the plane of the vertical circle, V, of the two-circle goniometer (see page 25); and to that of the horizontal circle, H, of the contact goniometer (page 46).

PROPERTIES OF THE GNOMONIC PROJECTION[1]

Figure 5 shows in perspective the relations of the gnomonic and spherical projections. It is clear that a face of the crystal to which the radius MF is normal is represented by the points F′ and F on the sphere and plane respectively. Let figure 6 be a

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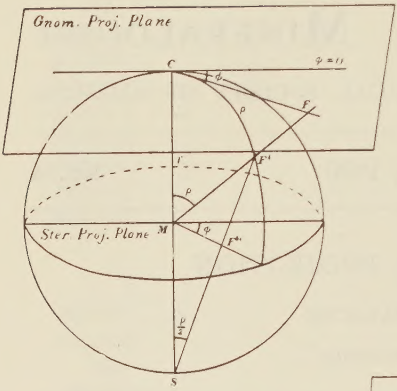
[1] The majority of the figures have been taken, with slight modification, from Boeke's book (see bibliography, 3).


Gnom. Proj. Plane
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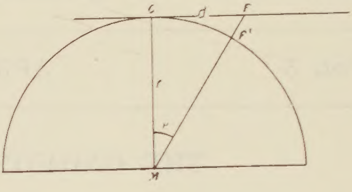
5


C
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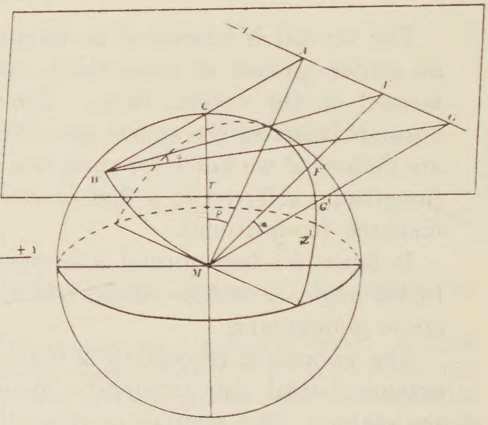
6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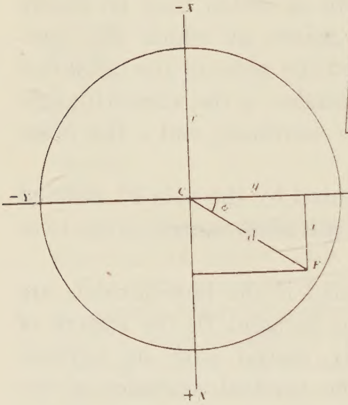
8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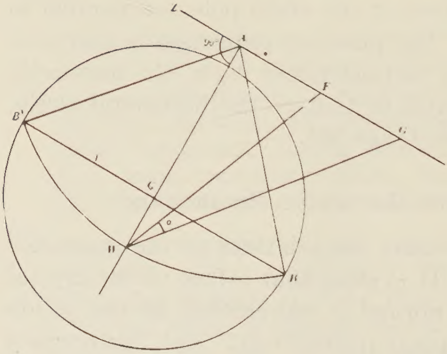
7


Z
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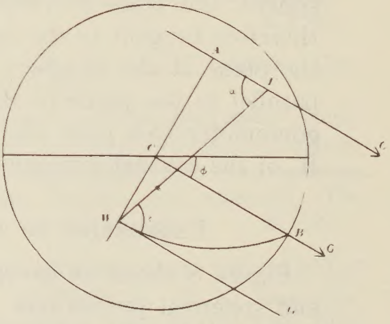
A
F
a
C
C
φ
W
B
G
G

10

central section of the upper half of the sphere containing the face normal and the radius MC.

$$\frac{CF}{r} = \tan \rho;\ CF = r \tan \rho;\ \text{if } r = 1,\ CF = \tan \rho = d.$$

In general usage r is taken as 5 cm.; therefore the central distance of a face in gnomonic projection, $d = 5 \tan \rho$ cm.

Figure 7 shows in plan the gnomonic projection of the face F of figures 5 and 6. C is the projection of the polar axis and the center of the unit circle with the same radius as the sphere. Let r = 1. X and Y are rectangular coördinates thru C. F is the pole of the crystal face whose angles are φ and ρ.

The position of F is determined by its polar coördinates φ and $d = \tan \rho$. It may also be determined by rectangular coördinates:

$$\sin \varphi = \frac{x}{d} = \frac{x}{\tan \rho}, \quad x = \sin \varphi \tan \rho,$$

$$\cos \varphi = \frac{y}{d} = \frac{y}{\tan \rho}, \quad y = \cos \varphi \tan \rho.$$

Considering figure 5 and remembering that projection is by means of radii of the sphere, it will be evident that zones of the crystal which are projected as great circles of the sphere will appear in the gnomonic projection as straight lines. Conversely, the straight line connecting any two gnomonic face-poles represents a zone of the crystal. A crystal face belonging to two zones of the crystal lies at the intersection of two zone lines of the projection. Conversely, the intersection of any two zone lines of the projection is the pole of a possible crystal face.

Poles of faces of the lower half of the crystal are represented by the poles of parallel upper faces.

Faces near the equator have their poles projected to great distances from C; faces on the equator (prism faces) are projected by lines parallel to the plane of projection or to infinity and are defined therefore only by direction lines. This circumstance is the greatest drawback of the gnomonic projection. Working with the usual 5 cm. radius faces with ρ greater than 75° do not appear in a projection of workable size.

The poles of all the faces of a crystal, located by plotting for each φ and $\tan \rho$, or x and y from measurements, constitute the gnomonic projection of the crystal.

CONSTRUCTION OF A GNOMONIC PROJECTION

The plotting of coördinate angles is done most readily on a sheet provided with a divided circle. Penfield's sheets for stereographic projection serve excellently, a 5 cm. circle being drawn within the divided circle for gnomonic constructions.

Several cases may arise which will be successively described.

1. Given the observed angles of a crystal, v and h; symmetry and the position of the zero meridian of the crystal unknown.

The pole distance, ρ, is found for each face by subtracting its h reading from h_0 (see p. 27.)

The vertical circle of the goniometer corresponds, and is parallel, to the plane of projection. The graduation of this circle may therefore be conceived as superposed upon the divided circle of the drawing sheet. Calling any point on the circumference of the latter zero, say the right hand horizontal diameter, consider the divisions as increasing clockwise to 360°. Selecting now the measurements of any face of the crystal, note its v angle, find the corresponding division of the divided circle, and lay a centimeter scale or a gnomonic protractor with its zero at the center and its edge thru the selected point. It is well to mark this point with a needle until the scale is in position. Now find from the tangent table or from the edge of the protractor the distance corresponding to the angle ρ and prick the point with the needle, circle it lightly, and write beside it the number of the face from the notes. This is done for each face, prism faces being indicated by direction lines with an arrow and the face number. Thus a projection develops on the paper, consisting of the face-poles and prism direction lines. The eye quickly catches in such a projection the alignment of the poles in major zones, which may be drawn with straight-edge and triangle. Symmetry, or the lack of it, is easily established, especially if there are many faces. This method of plotting is rapid and useful for preliminary study of the measurements. It is particularly instructive to beginning students, for it gives an exact picture of the measurements without averaging or adjustments and is almost free from any assumption as to the grouping of the faces. Its main disadvantage is the skew position in which the projection generally lies with reference to the outlines of the drawing sheet, which may be inconvenient when other drawings are to be made on the same sheet.

2. Given φ and ρ. Symmetry known.

With the symmetry known the zero meridian can be established and the value v_0 in terms of the readings on the vertical circle may be determined. One solution for v_0 is graphic by the procedure just described.

The form (010), whose direction line will have $\varphi = 0$ and $v = v_0$, may be present, or it may be defined only by other faces. An example of the calculation of v_0 for a triclinic crystal will be given in a later paper in this series. It can usually be found by averaging pairs of readings of v for prisms or pyramids disposed symmetrically to (010). v_0 being known, it is to be subtracted from the v angles in such a way that the resulting φ angles shall not exceed 180°, plus or minus. This is done by making use of one or other of the relations[1]:

$$+\varphi = v - v_0 \text{ or } (360° + v) - v_0. \quad -\varphi = v_0 - v \text{ or } (v_0 + 360°) - v.$$

By writing v_0 on a slip of paper which can be held just above or beneath the successive angles in the v column a glance will show which of the equations to use and the difference, easily calculated mentally after a little practice, is entered in the φ column to the right. The ρ angles are obtained by subtraction of h from h_0 in the same manner.

It is customary to make the right-hand end of the horizontal line on the paper the zero point for φ. φ is laid off from this point on the divided circle, plus or minus as the case may be and the ρ plotted as before. It is best to draw no zone lines until all poles are plotted. The zones and unit coördinates soon become apparent as plotting proceeds.

3. Plotting without a divided circle.

Draw the unit circle and horizontal and vertical diameters, dividing the circle into quadrants. The φ angle is plotted from a table of chords. Since the table reads only to 45°, when φ is over 45°, its complement, supplement, or $\varphi - 90°$ is taken and plotted from the appropriate quadrantal point. The chord length is taken with the dividers from the scale and transferred to the circle. ρ is then plotted as before.

This method is slow and has no special merit.

4. Plotting from Goldschmidt's *Winkeltabellen.* Polar elements and symbols of the forms given.

This may be done by plotting φ and ρ, as in 2; or by taking $d = \tan \rho$ from the tables; or from the rectangular coördinates, x and y, also given in the tables. It is accomplished more rapidly by plotting the three pinacoids and the unit pyramid from their φ and ρ; and drawing parallel coördinates thru this last pole. p_0 and q_0 are thus given graphically. The indices of the forms are transformed so that the third term of each is unity: $\left(\frac{h}{l}\ \frac{k}{l}\ 1\right)$ or (pq1) where p and q are either whole numbers or fractions. (The first two numbers constitute Goldschmidt's symbol.) Each pole is then located by measuring pp_0 and qq_0 with the dividers along the coördinates and drawing parallels to intersection.[1]

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[1] A rough sketch showing the unit circle with the value of v_0 written at the zero point will be found useful in applying these relations.

5. Plotting from linear axes and interfacial angles.

In the three rectangular systems it is only necessary to lay off the two angles (001) to (011) on the zero meridian; and (001) to (101) on the 90° meridian. These points give the values of p_0 and q_0 and the plotting proceeds from indices as in 4. In the hexagonal system, plotting the angle of a pyramid or rhombohedron face to the basal pinacoid gives the p_0 value. In the monoclinic and triclinic systems the center of coördinates is *not* the center of the circle. While it is easily possible to locate the pinacoid (001) by methods to be described in what follows, it is simpler to transform the linear axes, a and c, to their equivalent polar axes according to the relations to be given later. The plotting is then done as in 4.

FUNDAMENTAL CONSTRUCTIONS OF THE GNOMONIC PROJECTION

1. The angle-point. Measurement of the angle between two faces.

In the perspective figure 8 let F′ and G′ be two face-poles, the angle between which, $F'MG' = \alpha$, we wish to measure. The great circle containing F′ and G′ is projected into the straight line Z containing F and G. Imagine the triangle FMG rotated about Z as axis until it comes into the plane of the projection. M, the center of the sphere, will wander to a point W which is on a line CA, perpendicular to Z thru C. $AW = AM$. The angle $FWG = \alpha$ is the desired angle and can be measured with a protractor or by means of the chord table.

To find W, figure 9. Draw a circle about C with radius r (5 cm), equal to CM of figure 8. Draw CA perpendicular, and

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[1] Figure 17 illustrates a general case.

CBB′ parallel, to Z, the zone line containing F and G, two gnomonic face-poles. On the line AC take AW equal AB equal AB′. The construction requires no proof if we note that CB equals CM and that therefore AB = AM = AW.

Definitions.—The circle with center C is called the unit circle (Grundkreis). The perpendicular to the zone line thru C (CA of figures 8 and 9) is called the *central* (Zentrale) of the zone; the point A the zone center.

The point W is called the angle-point (Winkelpunkt) of the zone and is of much importance in many operations in the gnomonic projection. It must be evident from the construction that the angle-point W of any zone will always fall within the unit circle between C and the circumference; and it will lie upon the *central* beyond the center C from the zone line. If Z passes thru C (vertical zone) W will lie on the circumference. If Z is at infinity (prism zone) W will coincide with C.

Special Cases.—1. To measure the angle α between a face-pole, F, and a prism-pole G whose angle φ is given. Figure 10.

G lies at infinity in the direction of CG. Draw the zone line FG parallel to CG and find its angle-point, W. Draw WG′ parallel to FG. The angle FWG′ = WFA is the desired angle α.

2. To measure the angle between two prism poles. The angle is measured at the center between the two direction lines to the prism-poles and is equal to the difference between their φ angles.

3. To measure the angle between two faces having the same φ value (vertical zone). Figure 11.

W lies on the circumference of the unit circle on a radius normal to the zone. Otherwise the construction is the same as in the general case. If one of the poles G′ lies at infinity (prism-pole) its angle to F is given by the angle WFC.

Angular Relation of W, the Angle-Point, to C and A

The relations of W to C and any zone center A may be further explained by consideration of figure 12, a vertical section of the sphere of projection thru a *central* and therefore normal to the zone (compare figures 8 and 9).

Let A be the zone center, W the angle point and ρ the angle AMC which is given in the projection. The triangle AMW is isosceles since AM = AW. The angle θ equals $\frac{1}{2}(90^\circ - \rho)$[1]

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[1] The sum of the angles at *W* and *M* equals 180° less the angle at *A*. $180 - (90 - \rho) = 2\rho + 2\theta$. $90 + \rho - 2\rho = 2\theta$. $\theta = \frac{1}{2}(90 - \rho)$.

Now AM = r.sec ρ. Also CA = r.tan ρ; CW = r.tan θ = r.tan $\frac{1}{2}(90° - \rho)$. Therefore AW = r.tan ρ + r.tan $\frac{1}{2}(90° - \rho)$. Ingenious use of this relation is made by Hutchinson (8) in the use of a gnomonic protractor for rapid determination of the angle-point.

TO FIND THE GNOMONIC POLE OF A ZONE (EDGE-POLE)

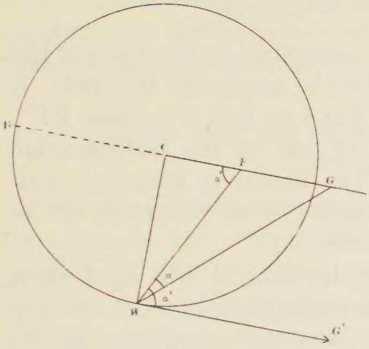
The edge-pole of a zone is the point on the sphere 90° from all points on the zone circle. In the perspective figure 13 P′ is the pole of the zone circle Z′. P the desired gnomonic pole must lie on the *central*, AC, at an angular distance of 90° from A. If the triangle AMP, right-angled at M, be rotated about AP into the plane of the projection, we have the relations of figure 14 and the construction is clear. Draw the *central* CA and CBB′ parallel to Z. Connect A and B and make ABP a right angle. The point P is the desired edge-pole of Z. The construction is more accurate if repeated at B′ as in the figure.

P may be regarded as the point of emergence in the gnomonic projection of the axis of the zone Z; that is of the line normal to it passing thru the center of the sphere. This line is parallel to the edges of intersection of the faces constituting the zone, whence the name, edge-pole, for P, following Hilton. It plays an important part in several operations in the gnomonic projection. P lies between the center of the projection (pole of the prism zone) and infinity (pole of a vertical zone).

SOME RELATIONS BETWEEN THE GNOMONIC AND STEREOGRAPHIC PROJECTIONS.

In figure 5 the relation between the gnomonic and stereographic projections of the pole F′ is shown in perspective. The two projections are on parallel planes separated by a distance equal to the radius of the sphere, r. In the first the point on the sphere (face-pole) is represented as tho seen from the center, M, of the sphere of projection; in the second the eye-point is at S, the south pole. F″, the stereographic pole of F′, is the point in which the line F′S intersects the equatorial plane.

It is evident that F and F″ will have the same azimuth angle φ, when referred to a common zero-meridian. On the other hand the central distances of the projected poles differ thus:


F
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α
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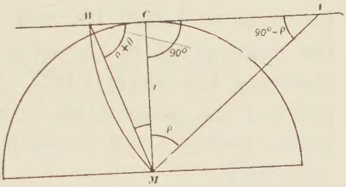
11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90°
90°-ρ
r
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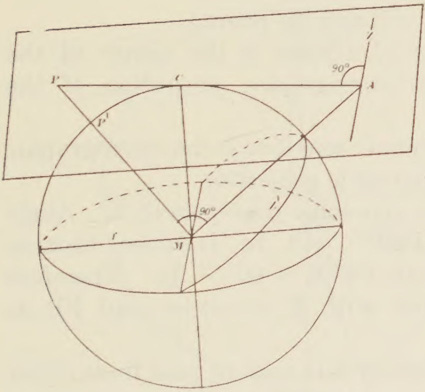
M

12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P
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A
P'
90°
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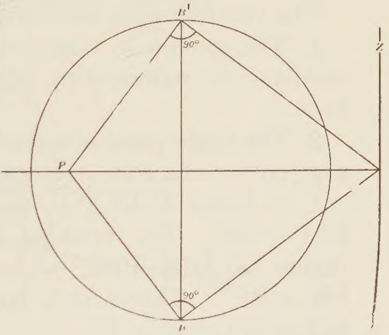
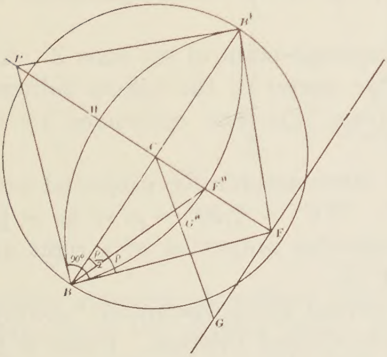
r
M

13


B'
90°
Z
P
90°
B

14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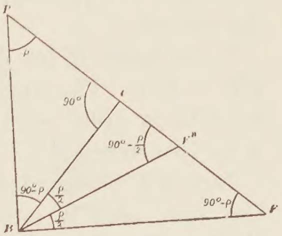
G


P
ρ
90°
C
90° - ρ/2
F''
90°-ρ
ρ/2
ρ/2
90°-ρ
F
B

16

gnomonic: $\quad CF = r.\tan \rho$

stereographic: $CF'' = r.\tan \frac{1}{2}\rho$

We imagine the two projections superposed in the plane of the paper as in figure 15; and let F be the gnomonic face-pole, B the angle-point, of the zone FC. Then to find F″, draw BF″, bisecting the angle FBC. B and B′ will be the stereographic poles of the prism faces in zone Z (at infinity in gnomonic projection) since for a prism $\rho = 90°$ and $CB = \gamma = r.\tan 45° = r.\tan \frac{1}{2}90°$.

The stereographic projection of the zone Z will then be a circular arc thru BF″B′. The stereographic pole, G″, of any other gnomonic face-pole in Z as G is at the intersection of CG with the arc BF″B′.

The two following relations will now be proved:

1. The gnomonic edge-pole of a zone is the center of the circular arc representing the stereographic projection of the zone.

2. The angle-point of a gnomonic zone-line is the stereographic edge-pole of the zone in stereographic projection.

1. In figure 15 let P be the gnomonic edge-pole of Z. Angle FBP = 90°. The triangle PBF″ will be isosceles because (figure 16) Angle PBF″ = Angle PF″B = $90° - \frac{1}{2}\rho$. Therefore PB = PF″. Therefore a circle with P as center and PB as radius will contain F″.

By means of this simple relation it is easy to pass from either projection to the other, zone by zone. It is more accurate to construct the stereographic projection from the gnomonic than the reverse.

2. In figure 15 let W be the angle-point of the zone Z. Then FW = FB. The angle at the center of the sphere subtended by CW is $\frac{1}{2}(90° - \rho)$ (see page 73); that subtended by CF″ is $\frac{1}{2}\rho$ (construction).

But WF″, regarded as a stereographically projected arc, is the sum of CW and CF″. $WF'' = \frac{1}{2}(90° - \rho) + \frac{1}{2}\rho = \frac{1}{2}90°$. WF″ is therefore the stereographic projection of a right angle and W is the edge-pole of BF″B′.

P and W, F″ and F are termed by Goldschmidt "conjugate points," and their relations are of much interest. P and W may be regarded, following the proof above, as points common to the two projections. W has the further identical property in both that it is the point at which angles between faces in the zone are measured. For the proof that the edge-pole of a stereographic zone is its angle-point, see any treatise on that projection, for example Boeke, (3) p. 14.

EQUAL SPACING OF ZONE LINES IN GNOMONIC PROJECTION

Since the gnomonic projection is obtained by projection thru face-normals, the central distance of a face does not affect the position of its projection point. It however simplifies the relations of the face symbols in the projection if all faces have a common point of intersection in the plane of the projection.

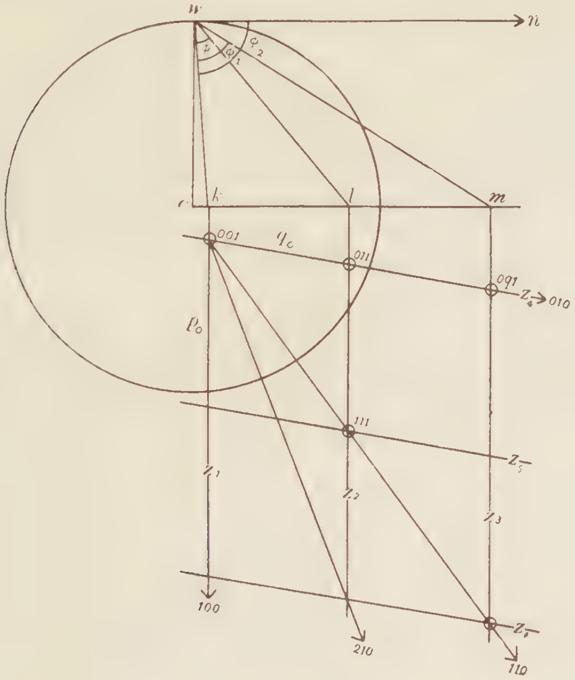


FIG. 17

Therefore conceive this plane normal to the c axis at a unit distance from the crystal center and let each face be shifted parallel to itself until it cuts that axis at unity. The Miller index of any face (hkl) will then become $\left(\frac{h}{l}\ \frac{k}{l}\ 1\right)$ which we may call (pq1). Let figure 17 be a gnomonic projection of a triclinic crystal and choose as coördinate directions the two pinacoidal zones [(001): (100)] and [(001: 010)]. Then it is true as first shown by Goldschmidt that if the unit pyramid (111) has the gnomonic coördinates p_0 and q_0, the coördinates of any face (pq1) will be pp_0 and qq_0. Since however the projection of any face-pole may be regarded as the intersection point of two zones parallel to the coördinate axes we may state the relation in the following form:

The zone lines are equidistant whenever p or q respectively increases by a like amount.

The proof involves constructions shown in the figure.

Let z_1 be the coördinate zone-line (001) to (100).

Let z_4 be the coördinate zone-line (001) to (010).

Let z_2 be the zone-line (011) to (100) determined by the coördinate q_0 of (111) measured in z_4.

Draw z_3 parallel to z_1 and z_2 so that the distance from z_2 equals the distance of z_2 from z_1.

Now the angles between the three zones are measured at the angle-point W of the common *central* to the zones, Cklm.

φ = kWl = angle (001) to (011),

φ_1 = kWm = angle (001) to (0q1),

φ_2 = kWn = angle (001) to (010).

If the face (0q1) is a crystallographically possible face then the pencil of rays at W, (k, l, m, n) must conform to the well-known condition that the anharmonic ratio of four poles in a zone must be rational (Tutton, *Crystallography*, p. 76).

That is,

$$\frac{km}{kl} \cdot \frac{nl}{nm} = \frac{\sin \varphi_1}{\sin \varphi} \cdot \frac{\sin (\varphi - \varphi_2)}{\sin (\varphi_1 - \varphi_2)} = \text{a rational quantity.}$$

Since n is at infinity, nl/nm = 1 and we have the simple relation: km/kl = a rational quantity. But km: kl = (0q1) (001) : (011) (001) = 2 : 1 (construction).

Therefore we may conclude that the zone containing 0q1 with a coördinate $2q_0$ is a possible crystal zone and we may write the symbol of the face (021). An exactly similar relation may be proved for the parallel zones z_4, z_5, z_6; and the conclusion follows that the principal zones in gnomonic projection are equally spaced in any given direction, p_0 and q_0 being the respective measures along the axial or coördinate directions. All faces in zone z_3 will have the second index 2 and similarly faces in z_6 will have the first index 2. The face at their intersection $2p_0$ $2q_0$ will therefore be (221).

This most remarkable property of the gnomonic projection gives it its greatest usefulness in graphical crystallography. A projection made from the measured angles gives at once the direction of the dominant zones as well as the constants p_0 q_0 measuring the interspaces in those zones. These constants having been fixed by the choice of the unit pyramid, the symbol of any face may be at once established by determining graphically the coördinates pp_0 and qq_0, giving the symbol for the face (pq1). For prism faces the ratio p : q or $pp_0 : qq_0$, determined by the coördinates of some face thru which the direction line of the prism passes, fixes the symbol of the form as shown in the figure.

Further, as soon as the coördinate directions and the position of any pyramid face with known indices are established, all other possible faces of the crystal may be constructed by expanding the net of parallelograms so outlined.

In later papers it is proposed to describe the characteristics of the projection in each crystal system; the methods of calculation employed; and the relations existing between the elements p_0 and q_0 and the linear elements, a, b and c.

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Brings out the relations of the two projections.

3. Boeke, H. E. Die gnomonische Projection. Berlin, 1913.

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   An excellent paper devoted to graphic solution in terms of polar coördinates but of the linear elements.
7. Hilton, H. The Gnomonic Net. *Min. Mag.*, **14**, 18, 1904.
   A device similar to the stereographic net, useful for graphical determination of the angles between poles in gnomonic projection.
8. Hutchinson, A. A Protractor for Use in Constructing Stereographic and Gnomonic Projections of the Sphere. *Min. Mag.*, **15**, 93, 1908.
   A simple wooden protractor for rapidly plotting both projections. Also historical notes on the two projections.

THAUMASITE (AND SPURRITE) FROM CRESTMORE, CALIFORNIA[1]

W. F. FOSHAG

U. S. National Museum

The contact-metamorphosed limestone at Crestmore, near Riverside, California, has yielded a large array of interesting minerals, including the species wilkeite with four acid radicles. During the summer of 1918 the mineral thaumasite, which contains three acid radicles, was found at the quarries. The first specimens discovered consisted of small masses of interlaced needles resembling the "cotton ball" ulexite. The needles were very fine and under the microscope appeared as long prisms terminated by the base or, less frequently, by a pyramid and base. The angle between the pyramid and base measured under the microscope was about 45°. Later small slender crystals and short stubby ones in parallel growth were found lining cavities and massive silky veins up to 3 cm. cutting across the contact rock. The veins closely resemble those carrying the thaumasite in Beaver Co., Utah, described by Butler and Schaller.[2]

An analysis of the mineral gave the following results:

SiO_2 9.10, $(Al, Fe)_2O_3$ 0.84, CaO 12.98, SO_3 27.56, $H_2O + CO_2$ (ign.) 49.48, sum 99.96 per cent.

The most significant feature of the occurrence is the mode of genesis of the mineral. It coats blocks of rocks thought at first to consist of monticellite, which occurs abundantly at the quarries. These blocks often have concentric shells about their outer surfaces, the space between the shells being filled with thaumasite. The supposed monticellite, upon analysis, was found to have about the composition of oakermanite,[1] but optical examination showed it to be made up of two minerals. The presence of a mineral with well-developed polysynthetic twinning similar to that of albite, together with the analytical recognition of a considerable content of CO_2 suggests the rare mineral spurrite. Samples were submitted to Dr. E. S. Larsen of the U. S. Geological Survey who determined the mineral definitely as spurrite with the following properties as compared with the original material from Velardeña, Mexico:

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[1] Published with the permission of the Secretary of the Smithsonian Institution.

[2] Am. J. Sci., [4] **31**, 131, 1911.

Crestmore	*Velardeña*
Polysynthetic twinning.	Polysynthetic twinning.
$\alpha = 1.638$	$\alpha = 1.640$
$\beta = 1.676$	$\beta = 1.674$
$\gamma = $ ——	$\gamma = 1.679$
$2V$ small	$2V = 39°5'$
Dispersion ——	Dispersion inclined
Optically −	Optically −
Twinning lines nearly normal to acute bisectrix. Optical plane across the lamellas.	Twinning lines nearly normal to acute bisectrix.

The CO_2 content, 4.64 per cent, indicates that spurrite constitutes about one half the rock; and from his petrographic examination Dr. Larsen estimated that the spurrite was present to the extent of about 50 per cent. of the sample.

Evidently, then, the thaumasite was derived from spurrite by the action of sulfated waters. No other evidence of sulfates is at hand, however, except the small amount present in the crestmoreite and riversideite as impurities, and that in the wilkeite.

It is planned to revisit this interesting locality, and a further study of the spurrite, together with an extended examination of all the minerals found there, will be undertaken.[2]

[1] The spelling of this name adopted for use in this magazine requires a word of explanation. The initial letter in Swedish is å; but as this character is not represented in the English alphabet, the nearest equivalent, oa, is used. It is pronounced as in oak.

[2] Mr. Foshag started on a trip to Crestmore while this article was in course of publication. Ed.

THE OLD LITHIA MINE IN CHATHAM, CONN.

EARL V. SHANNON

U. S. National Museum

At several places in North America attempts have been made at one time or another to mine lepidolite for its lithia content. One such lithia mine is located in Connecticut and, while little or no lepidolite from here was ever marketed, several tons were mined many years ago and the mineral still remains in a pile and furnishes abundant fine specimens to any mineralogist fortunate enough to find the locality. The writer was enabled to find the old opening by the aid of careful descriptions kindly furnished by Prof. Wm. North Rice of Wesleyan University. The location is described below.

While in southern New England on collecting trips the writer has experienced the greatest difficulty in finding old and famous localities; a search of the literature on mineralogy yields very little definite information. For instance, the paper on the minerals of Haddam published some years ago in the "*Mineral Collector*" is especially useless in this respect. It is highly desirable that contributors of articles prepared especially for the benefit of collectors should keep in mind the fact, that others will follow with no knowledge of the geography of the region other than that contained in their paper. Points located with reference to recognizable places on a U. S. Geological Survey topographic map are best. Careless, indefinite, phrases are often misleading. For instance, the writer once set out to find a certain mineral occurrence in Massachusetts, which was described as forming a prominent bed "opposite the school southwest of West Ware." On reading this description one would expect to be able to walk up to the bed in the dark yet three whole days were spent searching for the locality without success. For this reason considerable space should be allotted to telling in unmistakable terms just where a given source of minerals is.

In the present instance, the locality is contained in the area covered by the Middletown topographic sheet. On the north line of Haddam or the south boundary of Chatham township a prominent crossroad is shown, one road running north to Middle Haddam, one extending southward past Gillette's quarry to a landing opposite Haddam village, one extending westward to the river and one extending eastward along the town line. North of the town line and east of the north-south road is a farmhouse not shown on the map. To find the lepidolite locality one must follow a dim road which runs east past the barn alongside this farmhouse up the hill. At the top of the first rise the road, which is somewhat faint and obscure, detours around the south edge of a ledge of pegmatite. By leaving the road here and traversing the top of the pegmatite ledge the spot in question is found in a clump of birches about 30 meters north of the road.

The "mine" is a small cut somewhat filled in with soil and leaves; around it are piled heaps of white quartz and lepidolite. Lepidolite forms more than half of all the material removed from the pit, and large blocks of the pure mineral occur. It varies somewhat in texture and appearance. Some masses are composed of bright small scales of a beautiful deep purple-pink color, intergrown with fine platy clevelandite stained yellow brown by iron, the contrast in colors yielding very showy specimens. Other coarser scaly masses are pale lavender to gray in color and much of the material shows small spheres up to the size of a pea composed of folia of grayish lepidolite embedded in white clevelandite.

The only other abundant mineral in the pegmatite is quartz which is crystalline milky white, and resembles common vein quartz. Potash feldspar is entirely absent. Clevelandite albite occurs in masses of white plates and these contain bunches and masses up to several inches across of a flesh red to brownish red material resembling massive garnet, which upon analysis proves to be triplite. The triplite will be more fully described in another paper. In places the triplite has oxidized to a black manganese oxide, which stains the clevelandite. Occasional crystals of muscovite, which occur in the clevelandite, are penetrated by flat opaque crystals of green tourmaline. This lithia-rich mass seems to form a small segregation of later intrusion in a large dike of ordinary granite pegmatite. A short distance further east across a small swampy basin is a second much larger ledge of pegmatite which has been much explored by blasting. It is devoid of accessory minerals, small blocks of graphic granite of good pattern being the only thing of possible interest to the collector. It seems as tho all of the rarer constituents of the two great pegmatite masses have been segregated in the small vein where the lepidolite occurs. These dikes probably represent the continuation of the same pegmatite mass opened in the famous Gillette's Haddam neck quarry.

About $1\frac{1}{2}$ kilometers (two miles) north of the lepidolite mine is an old quarry which, according to Bastin[1] has yielded achroite tourmalines, etc. It is located on a low knob just south of an east-west road. It is abandoned, and shows now no sign of tourmaline-bearing pockets, or of clevelandite, lepidolite or other interesting minerals. The quarry face shows normal granite-pegmatite too rich in biotite and black tourmaline to be of economic value. Some small rose-red garnets and specimens of biotite and muscovite in parallel position were the only things brought away from this quarry, which is scarce worth a visit.

NOTES AND NEWS

We regret to announce the death of Professor Alfred J. Moses, of the Department of Mineralogy of Columbia University, on February 27th. An account of his life and work will be published in our pages in the near future.

We regret also to note the deaths of two veteran Pennsylvania mineral collectors: Mr. Thomas Harvey, Boothwyn, Pa., on November 5th, 1919; and Dr. John Fraley Rose, Oxford, Pa., on January 27th, 1920.

Mr. Harvey was an active collector, accumulating a wealth of Delaware County minerals, in particular those from the pegmatites of the Boothwyn District. He presented his collection to The Academy of Natural Sciences of Philadelphia in the spring of 1919. The monazite crystals described and figured in the October, 1919 number of this magazine were chiefly from his collection.

Dr. Rose discovered the peculiar vermiculite named after him by Genth, roselite. His collection is being offered for sale. S. G. G.

A recent issue of the Yonkers (N. Y.) *Herald* announces that Mr. Edwin C. Mott, collaborating with City Engineer Lawrence Griffith, is furnishing the city with a display of minerals for educational purposes. About 700 specimens of minerals, ores and rocks are now at hand, and most of them are on exhibition in cases in the City Hall furnished by the city. Among those who have contributed specimens are Col. William Boyce Thompson, Rev. August Ulmann, Dr. James T. Gibson, Alfred M. Beale, Theodore R. Heinrichs, James Cook, H. Armo Smith, American Museum of Natural History, thru H. P. Whitlock, New York State Museum, thru Harry F. Gardner, Lester M. Clutterbuck, C. W. Hoadley, John A. Manley, C. B. Church, and George B. Dowling. Mr. Whitlock has aided Mr. Mott in arranging the collection, and is to give a series of elementary lectures on mineralogy and related subjects.

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[1] *Bull. U. S. G. S.*, **420**, p. 47.

PROCEEDINGS OF SOCIETIES

NEW YORK MINERALOGICAL CLUB

Regular Monthly Meeting of Wednesday, February 11, 1920

The regular monthly meeting of the New York Mineralogical Club was held in the Academy Room of the American Museum of Natural History on the evening of February 11th, at 8.15 P.M. The President, Dr. George F. Kunz presided and there was an attendence of 33 members and visitors. Mr. M. L. Morgenthau and Mr. Antonio Espositer were proposed for membership.

Proceeding to the discussion of the evening, the subject of which was Siliceous Wood Replacements, Mr. Whitlock discussed the general problem, and showed how the opalized wood specimens from Virgin Valley, Nevada, tended to throw light upon the sequence of colloidal silica replacement, in this instance from hot solutions. The question at issue is, does the process of opalization proceed from a nucleus outward, ultimately filling the cavity, or does it take place inward, after the manner of formation of a geode.

Mr. Ashby pointed out that agatized wood ordinarily shows no traces of the bark preserved in the process of silicification. In discussing this statement, Mr. Allen called attention to a specimen of agatized wood which showed evidence of bark, and described microscopic slides made from it. Mr. Manchester exhibited a specimen of agatized wood showing quartering. Mr. Walker exhibited a specimen of wood partly changed to lignite.

Dr. Kunz discussed the formations from which the Arizona fossil wood is obtained, drew attention to its structure, and confirmed the statement of Mr. Ashby that no specimen had been obtained which showed clearly an outer layer of bark. He advanced the theory that the tree fragments had floated down to their present location, losing in the process considerable material from the outer layers. He stated that wood replacement by agate and jasper was the result of silicification from cold solutions, while opalization indicated a hot or warm solution as the silicifying agent. He characterized the Nevada opalized wood as fire opal rather than precious opal, and advanced the theory that the colloidal centers were probably due to dehydration. In discussing the association of the fossil opal replacements, Dr. Kunz stated that the Nevada wood opals occur in beds of volcanic ashes, while the New South Wales opals are found in sandstone.

HERBERT P. WHITLOCK,
Recording Secretary.

PHILADELPHIA MINERALOGICAL SOCIETY

Wagner Free Institute of Science, February 12, 1920

A stated meeting of The Philadelphia Mineralogical Society was held on the above date with the Vice-president, Mr. Trudell, in the chair. Twenty-four members and visitors were present. The names of Mr. E. O. C. Acker, James Rahill, and R. Weckerly, were proposed for active membership.

Mr. John A. Manley addressed the society on "A Trip to Iceland." Mr. Manley described the geology of the island, its people and their customs, etc.

Due to the torrential character of the streams, the roughness of the country, and bad weather, Mr. Manley was obliged to forego active mineral collecting. It was rumored that the Iceland spar locality on the eastern coast was practically exhausted. A large number of pictures, and products of the island were exhibited. Upon the close of his interesting communication the speaker was tendered a vote of thanks.

Mr. Gordon exhibited a specimen of a new occurrence of thomsonite, as a druse of minute crystals, with natrolite, from Lenni, Delaware County. Mr. Warford exhibited spencerite from British Columbia, and several other minerals.

Samuel G. Gordon, *Secretary.*

MINERALOGICAL SOCIETY OF AMERICA

Committee on Affiliation with the Geological Society of America

At the invitation of the Council of the Geological Society of America, President Kraus of the Mineralogical Society of America appointed a committee of three, Messrs Kraus, Wherry, and Whitlock, to meet with a Committee of the Council of the Geological Society. The meeting took place in the office of secretary Hovey in the American Museum of Natural History, New York City, on Saturday, February 14, 1920; the representatives of the Geological Society present were Messrs. Hovey, Mathews, Shaw, David White and President I. C. White.

The matter of affiliation was fully discussed, and a tentative agreement was reached. This is to be taken up at the next meeting of the Council of the Geological Society of America, after which announcement will be made of the details of the plan of affiliation adopted. E. T. W.

NEW MINERALS

SPHENOMANGANITE.

G. Flink: Sphenomanganit von Långbanshyttan. (Sphenomanganite from Långbanshyttan. *Geol. Fören. Förh.*, **41** (4), 329–336, 1919.

Name: from the fact that it is a manganite of sphenoidal habit. This name is put forward provisionally; should it later be shown that all manganite is sphenoidal, the prefix may be dropped.

Crystallographic Properties

Same as for manganite, except that the crystals show a sphenoidal habit. The prominent sphenoid is 121 on right hand side. Rarely an ill defined left sphenoid is observed. Some of the crystals are of thick tabular habit. One new form *s*(140) is present.

Chemical Properties

Analyses by Mauzelius on small samples gave: (1) SiO_2 0.11, Sb_2O_3 0.25, Fe_2O_3 0.35, MnO 79.60, O 8.76, MgO 0.87, CaO tr., PbO 0.10, H_2O 10.16, sum 100.22. (2) Fe_2O_3 0.7, Mn_2O_3 81.1, MnO 8.1, MgO 0.6, BaO 1.6, H_2O 7.3, sum 99.4 per cent. Sp. Gr. = 4.29.

Occurrence

Occurs on calcite and barite at Långban (Långbanshyttan).

DISCUSSION

This should be classed as a variety of manganite until more work is done on the crystallography of that mineral.

W. F. FOSHAG.

PYROBELONITE.

G. FLINK: Pyrobelonit, ein neues Blei-Mangan-Vanadat von Långbanshyttan. (Pyrobelonite, a new lead manganese vanadate from Långbanshyttan.) *Geol. Fören. Förh.* **41** (5), 433–447, 1919.

NAME: From the greek words for fire and needles, in reference to its color and form.

PHYSICAL PROPERTIES

COLOR: fire to deep red. Luster: adamantine to submetallic. Form: long-prismatic needles, seldom over one mm. long. H = 3.5. Sp. gr. = 5.377. Brittle, with conchoidal fracture.

CRYSTALLOGRAPHIC PROPERTIES

Orthorhombic. a:b:c = 0.8040; 1 : 0.6509. Habit prismatic. Forms: (100), (110), (120), (210), (001), (011), (031), (111), (221). $110 : 1\bar{1}0$ = 77° 36′; $201 : \bar{2}01$ = 116° 36′. No cleavage observable.

OPTICAL PROPERTIES

Extinction parallel, elongation positive, pleochroism very faint, $c = \beta$, $b = \gamma$; the a axis is the acute bisectrix, $(-)$, n very high.

CHEMICAL PROPERTIES

COMPOSITION: a vanadate of manganese and lead with Mn: Pb = approx. 7 : 4. Analyses by Mauzelius on small portions gave: (1) V_2O_3 19.81, P_2O_5 0.05, PbO 48.99, FeO 0.51, MnO 25.03, MgO 0.66, CaO 0.62, H_2O ——, SiO_2 0.22. (2) V_2O_5 20.26, PbO 48.74, FeO 0.48, MnO 24.99, MgO 0.53, CaO 0.96, H_2O ——, SiO_2 0.22. Formula calculated to be $2PbO.\ 2MnO.\ V_2O_5 + 3(2PbO.\ 4MnO.\ 2H_2O.\ V_2O_5)$. [Simplified, becomes $11\ (Mn, Pb)\ O.3H_2O.\ 2Y_2O_5$.]

OCCURRENCE

Pyrobelonite occurs with hausmannite and barite on calcite. Other minerals more or less associated with it are native lead, barysilite, manganite, pyrochroite.

DISCUSSION

Flink shows that by changing the orientation of the crystals so that axis *a* becomes *c*, not only the crystallographic elements but also the optical properties are in close harmony with those of descloizite, and it probably belongs in the same group. Since the analysis was made on very small amounts of material, too much confidence should not be placed in the ratios derived from it. Instead of $RO : H_2O : V_2O_5 = 11 : 3 : 2$ as given, from which no reasonable formula can be obtained, it may be 5 : 2 : 1, as in dihydrite, ($5CuO.\ 2H_2O.\ P_2O_5$), or 4 : 1 : 1, as in descloizite, $4RO.\ H_2O.\ V_2O_5$, the crystallographic relations favoring the latter.

W. F. FOSHAG.

BAECKSTROEMITE.

G. Aminoff: Uber Bäckströmit, eine rhombische Modifikation der Verbindung Mn$(OH)_2$. [Baeckstroemite, an orthorhombic modification of the compound Mn$(OH)_2$.] *Geol. Fören. Förh.* **41** (6), 473–491, 1919.

Name: In honor of Helge Bäckström, Professor of Mineralogy at the Stockholm Advanced School. Since neither ä nor ö properly belong in the English alphabet, they are transliterated to ae and oe respectively.

Physical Properties

No physical or optical properties can be given, since the the material was largely altered to manganite.

Crystallographic Properties

Orthorhombic. a : b : c = 0.7393: 1: 0.6918. p_0 = 0.9357, q_0 = 0.6918.

No.	Letter	Gdt.	Miller	φ	ρ
1	b	0∞	010	0°00′	90°00′
2	m	∞	110	53 31	"
3	l	2∞	210	69 42	"
4	d	01	011	0 00	34 40
5	q	02	021	"	54 08
6	y	12	121	34 04	59 05
7	z	13	131	24 16	66 17
8	u	15	151	15 08	74 24
9	x	21	211	69 43	63 23

The angles show rather wide variations, but the means agree reasonably well with the calculated values.

Parallel growth of (0001) of pyrochroite upon (010) of baeckstroemite was observed. Some crystals show a good cleavage || to (010). Fairly close in ratios to orthorhombic Ca $(OH)_2$ and to Zn$(OH)_2$.

Chemical Properties

The mineral was largely altered to manganite. Analyses by Mauzelius: Altered baeckstroemite: Sb_2O_3 0.07, Fe_2O_3 0.14, Mn_2O_3 77.80, MnO 11.59, MgO 1.68, CaO 0.14, PbO 0.04, H_2O (+ 130) 5.16, H_2O (− 130) 3.24, Sum 99.86. Partial analyses on three other samples gave O_2 8.19, 8.15, 8.67; H_2O (+ 130) 8.59, 9.05, 8.57; H_2O (− 130) 3.54, 3.27, 3.65. Partial analysis of altered pyrochroite: O_2 8.26, H_2O (+ 130) 8.31, H_2O (− 130) 3.94. From these analyses it is concluded that the original compound had the same composition as pyrochroite, Mn$(OH)_2$.

Röntgenograms of the altered baeckstroemite on the face (010) give a figure similar to pyrochroite on (0001), indicating that the baeckstroemite has changed to the rhombohedral modification after its original formation. The crystals investigated then are double pseudomorphs, baeckstroemite→ pyrochroite→manganite.

Occurrence

Occurs in the limestone at Långban with pyrochroite and fluorite in close association. The baeckstroemite forms earlier than the pyrochroite.

Discussion

The evidence that baeckstroemite is a distinct species seems adequate.

W. F. Foshag.